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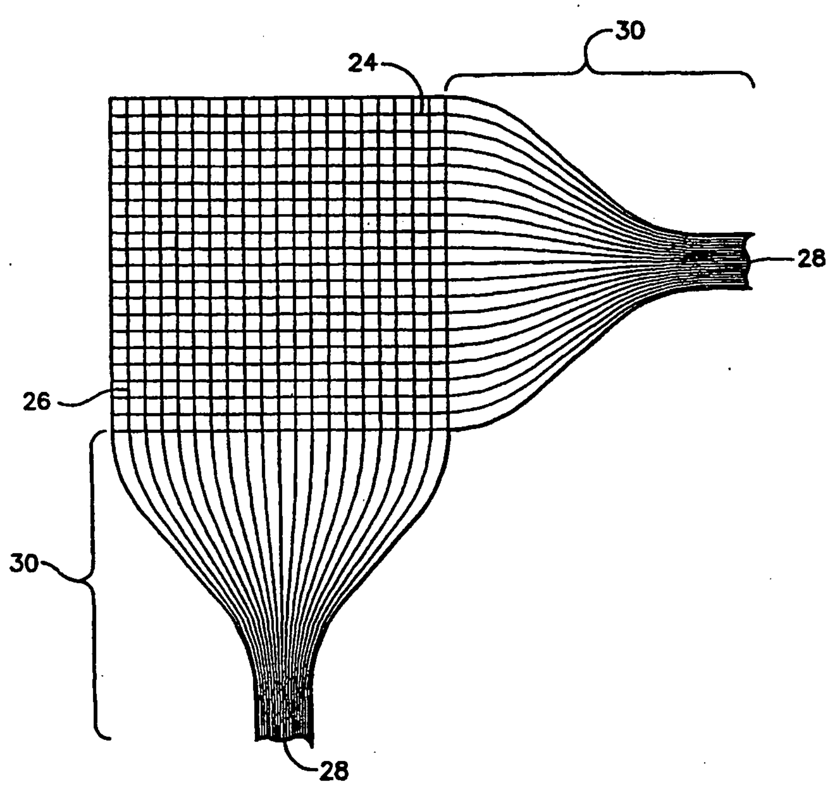
(54) Title: CARBON/CARBON COOLING SYSTEM

(57) Abstract

The present invention is directed to a carbon/carbon cooling system consisting of a carbon/carbon heat absorption plate for absorbing heat, a heater spreader plate preferably also made from carbon/carbon for dissipating heat, and a heat transfer conduit interconnecting the absorption plate and the heat spreader plate. The absorption plate is typically attached to the structure to be cooled thereby absorbing the heat generated by such structure. Heat from the absorption plate is then conducted to the spreader plate which dissipates the heat to an area away from the structure, thereby cooling the structure.



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CARBON/CARBON COOLING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a carbon/carbon cooling system and specifically to a cooling system for cooling structures such as circuit boards or circuit chips in computers.

Circuit boards and circuit chips in a computer generate heat. This heat adversely affects the life and reliability of such chips and circuit boards as well as the life of other circuitry in the computer.

To remove heat from such components, most computers currently use fans and/or heat sinks made from material such as aluminum. Typically, the heat sinks will be located proximate the circuit boards and chips to be cooled. A cooling fan may also be used to cool the board and chips. Moreover, a cooling fan may be used to cool the heat sink. The cooling efficiency, however, of a heat sink or a heat sink in combination with a cooling fan can stand improvement. In other words, more extensive cooling is desired so as to further extend the life of the computer and its parts as well as it reliability. As such, a system is needed that can effectively remove heat, i.e., cool, computer components so as to extend their life and reliability.

SUMMARY OF THE INVENTION

A carbon/carbon cooling system of the present invention incorporates a carbon/carbon heat absorption or heat sink plate and a spreader plate also preferably made from carbon/carbon. The heat absorption plate is interconnected with the spreader plate using a heat transfer conduit. Preferably, the heat transfer conduit is also made from carbon/carbon. The heat absorption plate is attached to the back of a circuit board or circuit chip. The conduit extends from the absorption plate to the spreader plate. The conduit may be integral with the absorption plate or the spreader plate. Alternatively, the absorption plate, conduit and spreader plate may be integrally formed from carbon/carbon.

The conduit is preferably formed by bundling and carbonizing carbon fibers. Preferably, these fibers are the ends of the carbon fibers forming the absorption plate. In other words, some portion of the fiber ends of the carbon/carbon absorption plate are bundled together and carbonized to form an integral conduit to the absorption plate.

The spreader plate is preferably mounted in a computer case such that at least one of its edges is exposed. Preferably, the spreader plate is sandwiched between an upper and lower portion of the computer case and does not extend all the way to the end

of the case. In this regard, a channel is formed by the upper portion of the computer case, the edge of the spreader plate, and the lower portion of the computer case. In a preferred embodiment, carbon whiskers extend from the exposed edge of the spreader plate and are contained within the channel. The channel enhances dissipation of heat from the spreader plate. The whiskers also enhance the dissipation of heat from the spreader plate. Since heat will travel along the carbon fibers, it is preferable that at least two opposite edges of the spreader plate are exposed. It is also preferable that the carbon fibers forming the spreader plate run perpendicularly to the two exposed edges.

Heat generated by the circuit board or circuit chip is absorbed by the absorption plate attached to the back of the circuit board or circuit chip and then transferred through the conduit to the spreader plate where it is dissipated to the outside of the computer case through the exposed ends of the spreader plate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an integrally formed carbon/carbon cooling system comprising a carbon/carbon heat absorption plate, a carbon/carbon spreader plate, and a carbon/carbon heat transfer conduit connecting the absorption plate to the spreader plate.

FIG. 2 is a top view of a cooling system comprising a carbon/carbon heat absorption plate with integral carbon/carbon heat transfer conduits and a carbon/carbon spreader plate with integral carbon/carbon heat transfer conduits.

FIG. 3 is a top view of a carbon/carbon heat absorption plate formed with unidirectional laid fibers, the ends of which are bundled together to form a heat transfer conduit integral with the absorption plate.

FIG. 4 is a top view of a carbon/carbon heat absorption plate formed using woven carbon/carbon prepregs having the welt fibers of the plate bundled together as well as the warped fibers of the plate bundled together forming two integral heat transfer conduits.

FIG. 5 is a top view of a carbon/carbon heat absorption plate having two transfer conduits extending from two edges which are connected to a single heat transfer conduit extending from a spreader plate.

FIG. 6 is a cross-sectional view depicting a cooling system mounted in a computer case.

DETAILED DESCRIPTION OF THE INVENTION

The carbon/carbon cooling system of the present invention can be used in a variety of applications. For example, it may be used to cool a circuit board or a circuit chip in a computer. As such, for descriptive purposes, the present invention is described in terms of a cooling system for a circuit board such as the one found in a computer.

The system consists of a carbon/carbon heat absorption or heat sink plate 10, a heat spreader plate 12 and an interconnection 14 between the heat sink and the heat spreader (FIG. 1). The system may have multiple interconnections 14 as shown in FIG. 2. When used as a cooling system for cooling a circuit board 16 in a computer, the heat sink plate is attached to the back of the circuit board and thus is sometimes referred to herein as the "backing plate." Attachment of the backing plate to the circuit board should preferably be accomplished using a thermally conductive adhesive. However, a mechanical arrangement is used.

The backing plate is a carbon/carbon plate. Generally carbon/carbon plates consist of carbon fibers embedded in a carbon matrix. Carbon/carbon has high thermal conductivity. The spreader plate may be made from any material that allows for the dissipation of heat absorbed by the backing plate. Preferably, however, the spreader plate is also a carbon/carbon plate. The spreader plate in the embodiment shown has a larger surface area than the backing plate to allow for better dissipation of heat. The interconnection is preferably a carbon/carbon bundle that extends from the backing plate and is connected to the spreader plate. A heat transfer cable may also be used. The interconnection is a heat transfer conduit. If the spreader plate is made from carbon/carbon, the bundle may be integral to the spreader plate.

The backing plate serves as a heat absorber. The heat transfer conduit (the "conduit") transfers the heat absorbed by the backing plate to the spreader where it is dissipated. Thus, the system of the present invention is used to remove heat from one location and transfer it to another where it is dissipated. As becomes apparent from the following description, the system is alternatively formed as a single unit or formed in sections, i.e., a modular arrangement. For example, the backing plate, the conduit and the spreader plate for the embodiment shown in FIG.s 3 & 4 are separate units. Alternatively, the backing plate with conduit a single unit as shown in FIG. 2, while the spreader plate is a separate unit. Alternatively, the spreader plate and conduit are a single unit, while the backing plate is a separate unit. In yet other embodiments, both the backing plate and the spreader plate have integral conduit portions. When forming the cooling system, these conduit portions are then connected to each other or to a

separate conduit. In yet a further embodiment, the backing plate, heat transfer conduit and spreader plate form a single unit.

Carbon/carbon composites such as plates are produced by numerous methods. In one method, plates are formed by laying up layers of carbon/phenolic prepregs. These layers are typically in tape or sheet form. The prepregs typically consist of carbon fibers impregnated with a phenolic resin. The prepregs may be unidirectional or in a woven form. Unidirectional prepregs are formed by impregnating fibers aligned in a single direction with a resin to form the tape or sheet. Woven prepregs consist of fibers woven to form a fabric that is then impregnated with a resin. The typical woven fabrics consist of a first set of fibers woven perpendicularly with a second set of fibers forming a fabric consisting of fibers running in the warp and in the welt directions.

To form the carbon/carbon composite plate, the prepreg layers are laid one on top of the other. If unidirectional prepreg tape is used, the prepregs may be laid such that the fibers from all the laid layers are aligned in a single direction. Alternatively, the layers are aligned in various directions. It is not uncommon for prepreg tape layers to be laid at 90° or 45° to each other. The same can occur with the woven tape. Of course, the woven tape already consists of fibers that are 90° to each other.

Once the prepreg layers are laid up to form a plate, the plate is autoclave cured, carbonized and then repeatedly re-impregnated with pitch or phenolic resin. Carbonization typically can occur up to five times before a desired high carbon/carbon density is achieved. Alternatively, carbon/carbon plates are formed by producing preforms of carbon fiber pultrusions that are then densified with carbon by either chemical vapor deposition or chemical vapor infiltration. This densification process is typically performed until the matrix is so dense that no more carbon can be deposited in the fibers.

The backing plate of the present invention is formed by any of the above or other conventional methods and should preferably have a carbonized bundle extending from at least one end. The heat absorbed by the backing panel will travel along its fibers. For this reason it is preferable that the bundle extends along the direction of the fibers so as to provide a continuous fiber path for the heat absorbed on the backing plates to travel toward the spreader plate. Typically, if the backing plate fibers are all aligned in a single direction then a bundle extending along that direction will be sufficient. However, if the plate consists of fibers aligned in multiple directions, then a bundle should preferably extend outward from the plate along each of those directions. Thus, for example, if the plate is formed using woven prepregs, then a first bundle should preferably extend along the warp and a second bundle should extend along the welt direction of the plate.

Preferably, the fibers forming the backing plate are aligned in one or at most two directions. When aligned in two directions, the fibers should preferably be perpendicular to each other.

The heat transfer conduit is typically formed by bundling at least some portion of the ends 18 of the fibers 20 extending to an end 22 of the backing plate (FIG.3). In an embodiment where the backing plate is formed using unidirectional prepregs laid in a single direction, the ends of the fibers forming an end of the plate are bundled together. Preferably, the bundles are formed to have either circular or rectangular cross sections 28. However, other cross-sectional shapes will also suffice. If woven prepregs are used then the ends of the fibers running along the warp 24 (and/or welt 26) direction and forming an edge of the plate are bundled as shown in FIG. 4. The laid prepregs and bundles are then autoclaved, cured, carbonized and repeatedly re-impregnated with pitch or phenolic resin to form the carbon/carbon backing plate with extending bundle.

In an alternate embodiment, prepreg layers are used to form the backing plate which do not have resin extending all the way to the ends of the fibers. In other words, the fiber ends 30 are not impregnated with a resin. These tape layers or woven layers are then laid to form the backing plate. The plate is then autoclave cured and carbonized as described above. The non-impregnated fibers are then bundled together and carbonized by either chemical vapor deposition or chemical vapor infiltration.

In a further embodiment, a preform of the backing plate with conduit is made from a carbon fiber pultrusion. The entire structure is then densified with carbon by chemical vapor deposition or chemical vapor infiltration.

Alternatively, the carbon/carbon backing plate may be formed separate from the conduit. The conduit and plate are then attached to each other using a thermally conductive adhesive or a mechanical arrangement. The conduit in such an embodiment is preferably formed by bundling and carbonizing multiple carbon fibers together.

In the embodiments where a carbon/carbon spreader plate is used, the spreader plate is formed in the same way as the backing plate. Such a spreader plate should preferably have the same number of extension conduit bundles as the backing plate.

The spreader plate may be thicker than the backing plate. In such a case, the extension bundle from the spreader plate may be larger in diameter than the bundles from the backing plate. If the spreader bundle is large enough, all of the bundles 34 extending from the backing plate may be connected to the single spreader bundle 36 (FIG. 5).

The spreader plate should preferably be positioned in a computer case 41 such that its edges do not extend all the way to the end of the case. Preferably, the spreader

plate is sandwiched between an upper portion 40 and a lower portion 42 of the case (FIG. 6). At least one of the edges 44 of the spreader plate should be exposed outside 46 of the case. In this regard, a channel 48 is formed between each exposed edge of the spreader plate and the upper and lower portions of the case. Although preferred, a channel does not have be formed along each exposed edge. The channel enhances heat dissipation. In addition, by forming a channel, the hot edges of the spreader plate are recessed away from the outer surface of the computer case. In this regard, the user of the computer is not exposed to the hot surface.

It is preferred that the ends of the fibers forming at least one of the edges of the spreader plate to be exposed are not impregnated with phenolic resin and are not carbonized. In this regard, when the spreader plate is carbonized, these fiber ends form whiskers 50. These whiskers aid in the dissipation of heat. The whiskers extending at the edge of the spreader plate preferably should be contained within the channel. If two opposite edges of the spreader plate are to be exposed, then it is preferable to form the spreader plate using unidirectional fibers extending to those edges. Whiskers should also be formed at those edges. Of course, if four edges are going to be exposed, then it is preferable to form the spreader plate with two sets of fibers laid at 90° to each other or with woven fibers. With such an arrangement, fiber ends can then extend to each plate edge.

The bundles of the backing plate are connected to the bundles of the spreader plate forming interfaces 52 (FIG. 2). Preferably they are connected using thermally conductive adhesive. Alternatively they may be connected mechanically. If connected mechanically, a thermally conductive grease should be used at the interface of the connection.

In an alternate embodiment, a separate carbon/carbon bundle is formed and is connected at one end to a bundle extending from the backing plate and at the other end to a bundle extending from the spreader plate. In yet another embodiment, a separate cable may be coupled to the backing plate and to the spreader plate to serve as the heat transfer conduit. With such an embodiment, the backing plate and spreader plates may be formed without any integral bundles. In a further alternate embodiment, the heat transfer conduit consists of a plurality of carbon fibers which are not carbonized.

As stated above, the backing plate, spreader plate and conduit are alternatively formed as a single unit. This may be accomplished in many ways. For example, a master plate is formed by laying up a plurality of carbon/carbon prepregs. A continuous backing plate, conduit and spreader plate is then cut out of the master plate using water jet, laser or other appropriate precision cutting method. The continuous structure is then

autoclaved and carbonized. Precision cutting is alternatively conducted after autoclaving. Alternatively, a section of the master plate between two of its edges is bundled to form the conduit. The unbundled portions on either side of the bundle form the heat spreader and heat absorption plates. The plate with bundle is then autoclaved and cured. In yet another embodiment, the portion of the prepreg layers forming a section of the plate are not impregnated with resin. These non-impregnated fibers are bundled and the plate with bundle are autoclaved and carbonized. In an alternate embodiment, the non-impregnated fibers are not carbonized. In yet a further embodiment, a preform of the unitary structure may be made from a carbon fiber pultrusion. The entire structure is then densified by chemical vapor deposition or chemical vapor infiltration.

With any of these embodiments, whiskers may be formed on the edges of the spreader plate as necessary.

The spreader plate is alternatively made from any other type of heat radiating materials. For example, the spreader plate may be made from aluminum. In such a case, the heat transfer conduit coupled to the backing plate is connected to the spreader plate preferably by a mechanical connection.

Each heat transfer conduit or bundle is connected anywhere on the spreader plate. For example, each conduit may be connected to an edge or an upper or lower surface of the spreader plate. Moreover, if a conduit or bundle is used that is separate from the backing plate, such conduit or bundle may also be connected on any surface of the backing plate. Such modifications and substitutions are within the scope and intent of the present invention as defined in the following claims.

WHAT IS CLAIMED IS:

1. A method for forming a carbon/carbon absorption plate with an integral heat transfer conduit comprising the steps of:

providing layers of carbon fibers impregnated with a resin up to an edge of the layers, wherein a portion of the fiber ends at the edge are not impregnated with the resin;

laying the layers one on top of the other to form the plate having edges;

bundling the non-impregnated fiber ends into a bundle;

autoclave curing the plate; and

carbonizing the bundled ends wherein the carbonized bundle forms a heat transfer conduit.

2. A method as recited in claim 1 wherein the step of providing layers comprises the step of providing unidirectional layers.

3. A method as recited in claim 2 wherein the step of laying comprises the step of aligning all layers in a single direction, wherein all of the non-impregnated fiber ends extend to the same edge of the plate.

4. A method as recited in claim 2 wherein the step of laying comprises the step of aligning all layers in more than one direction, wherein the non-impregnated fiber ends extend to more than one edge.

5. A method as recited in claim 1 wherein the step of providing layers comprises the step of providing woven layers.

6. A method as recited in claim 5 wherein the step of laying comprises the step of aligning all layers in a single direction, wherein all of the non-impregnated fiber ends extend to the same edge of the plate.

7. A method as recited in claim 5 wherein the step of laying comprises the step of aligning all layers in a single direction, wherein the non-impregnated fiber ends extend to the more than one edge of the plate.

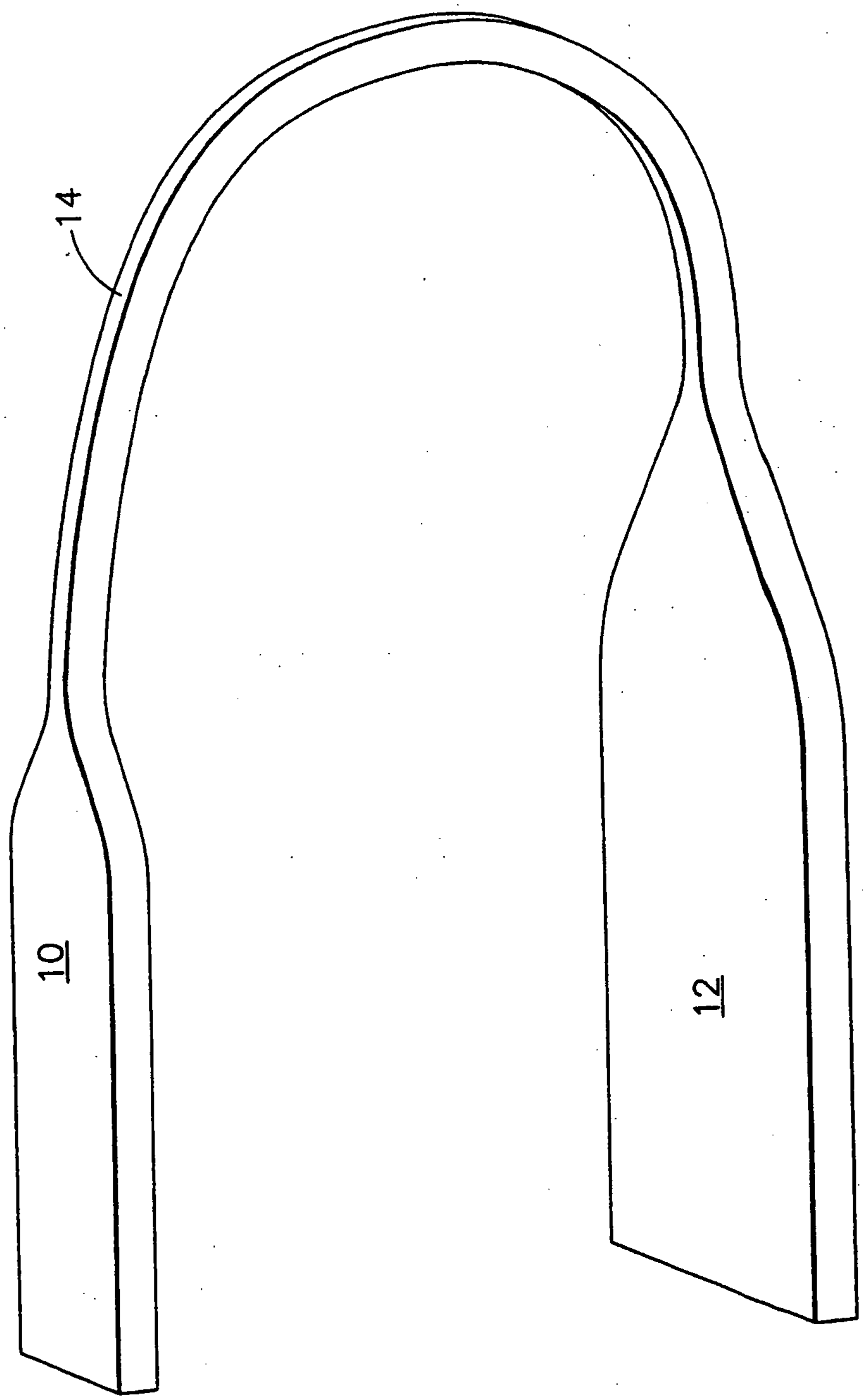

FIG. 1

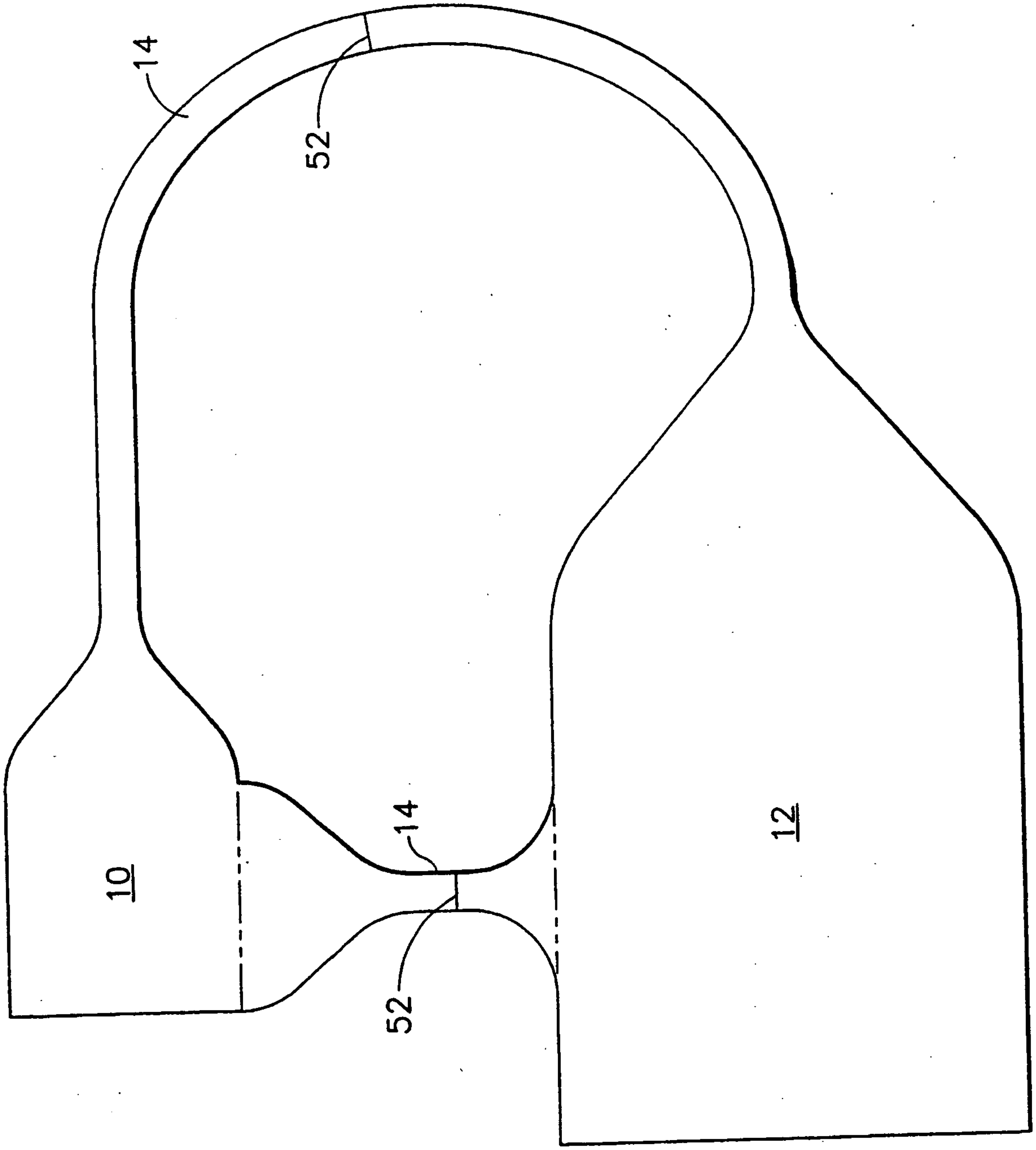

FIG. 2

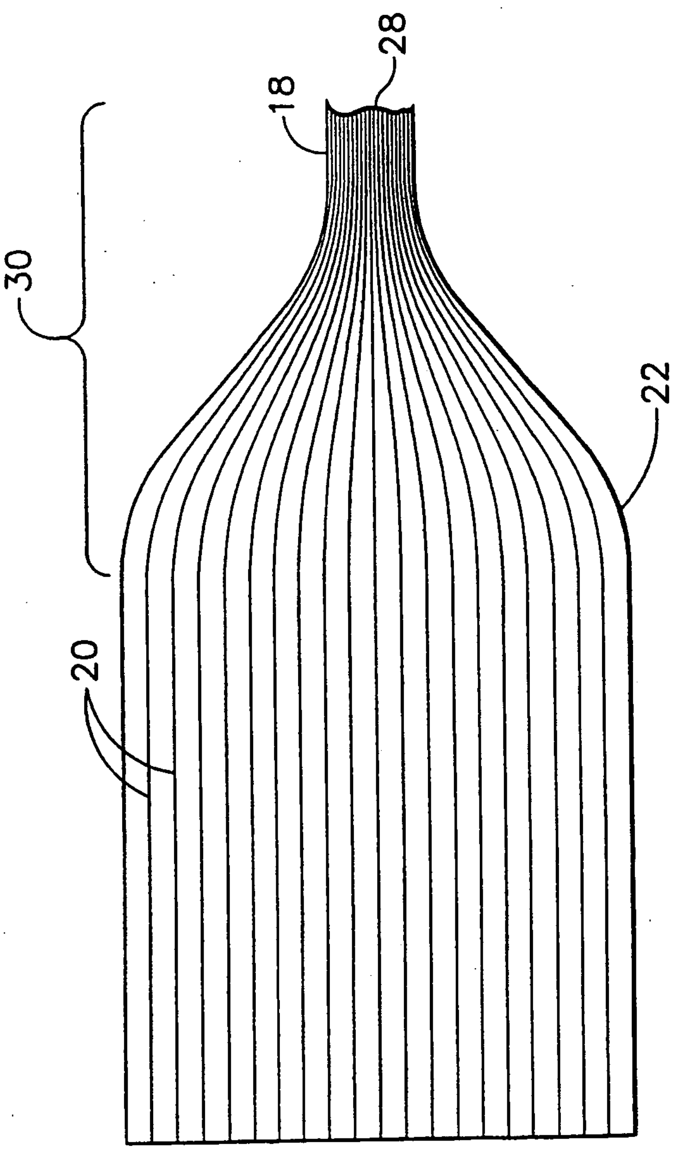

FIG. 3

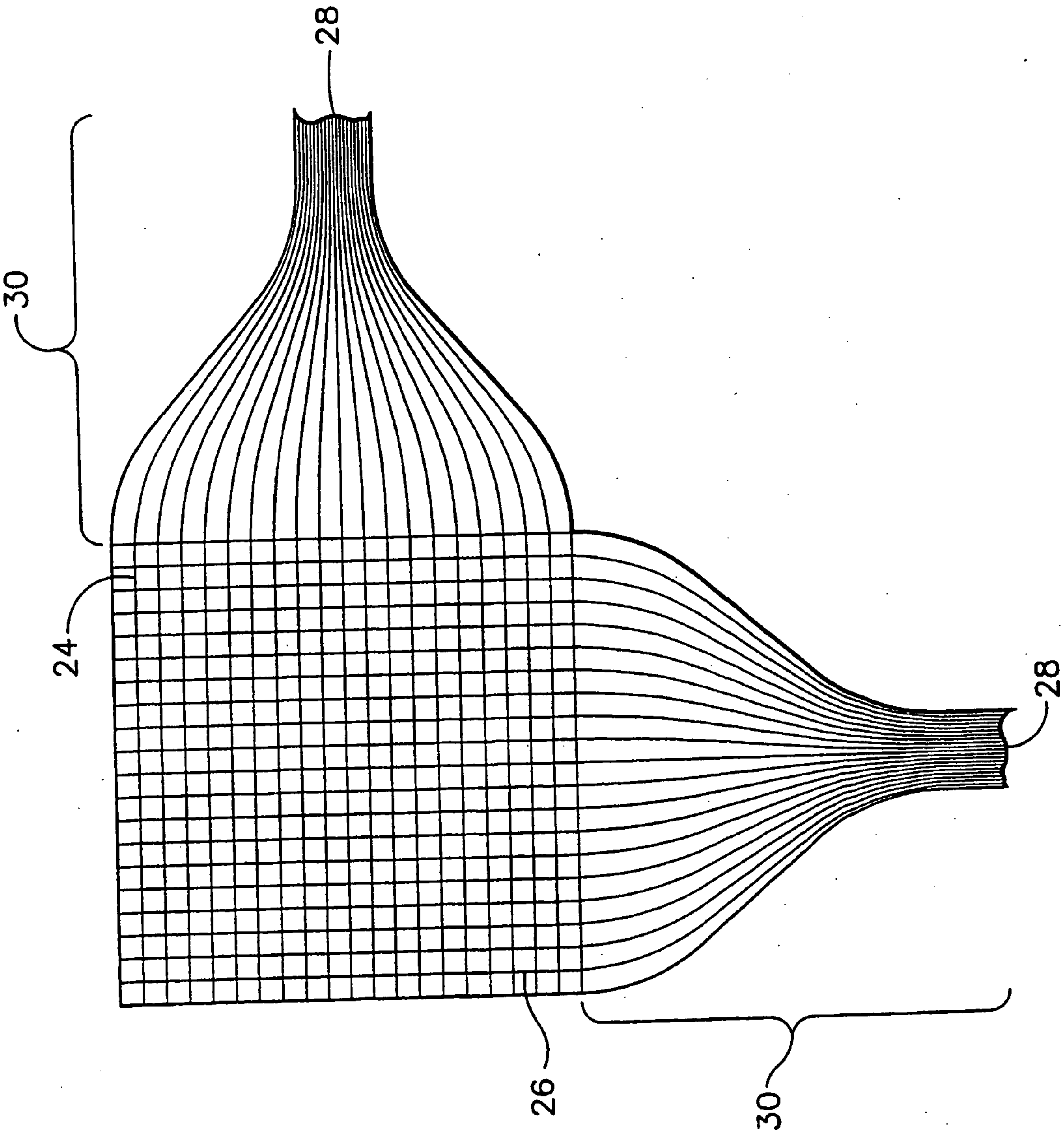

FIG. 4

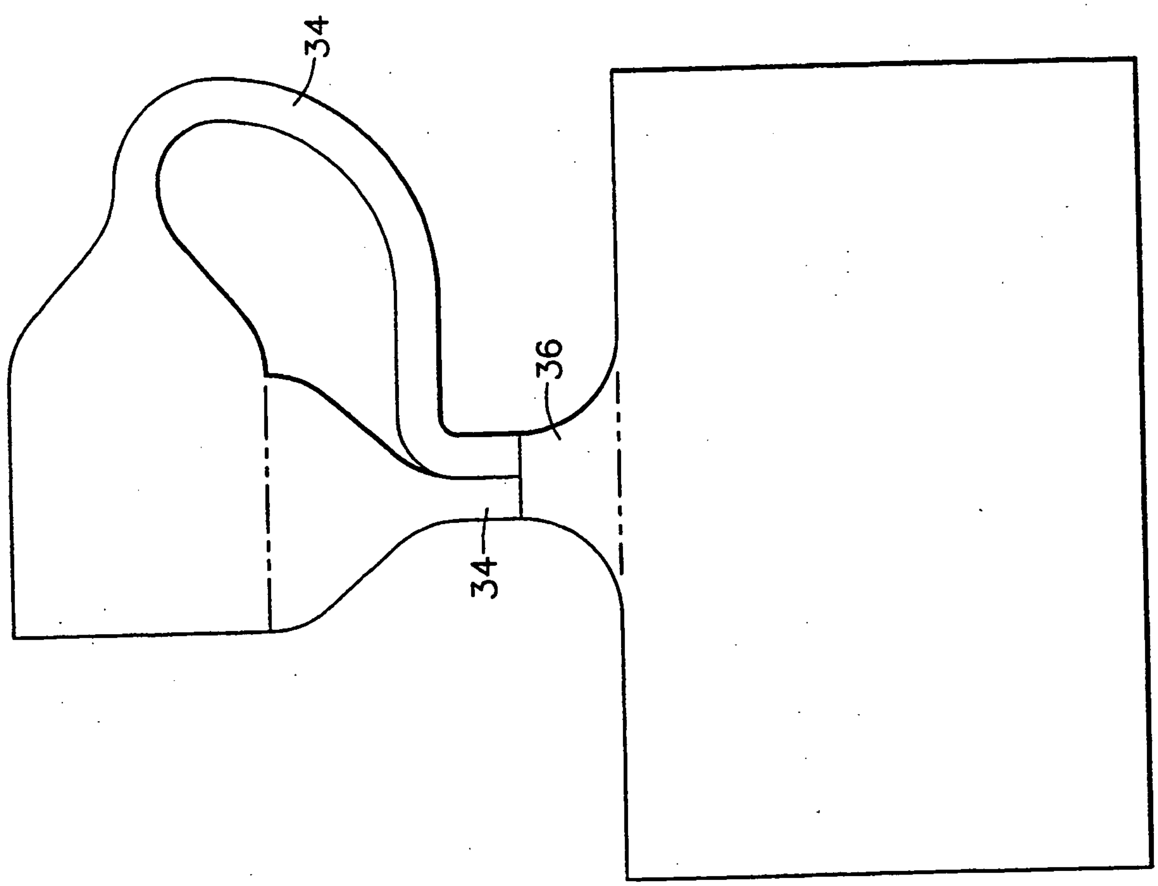

FIG. 5

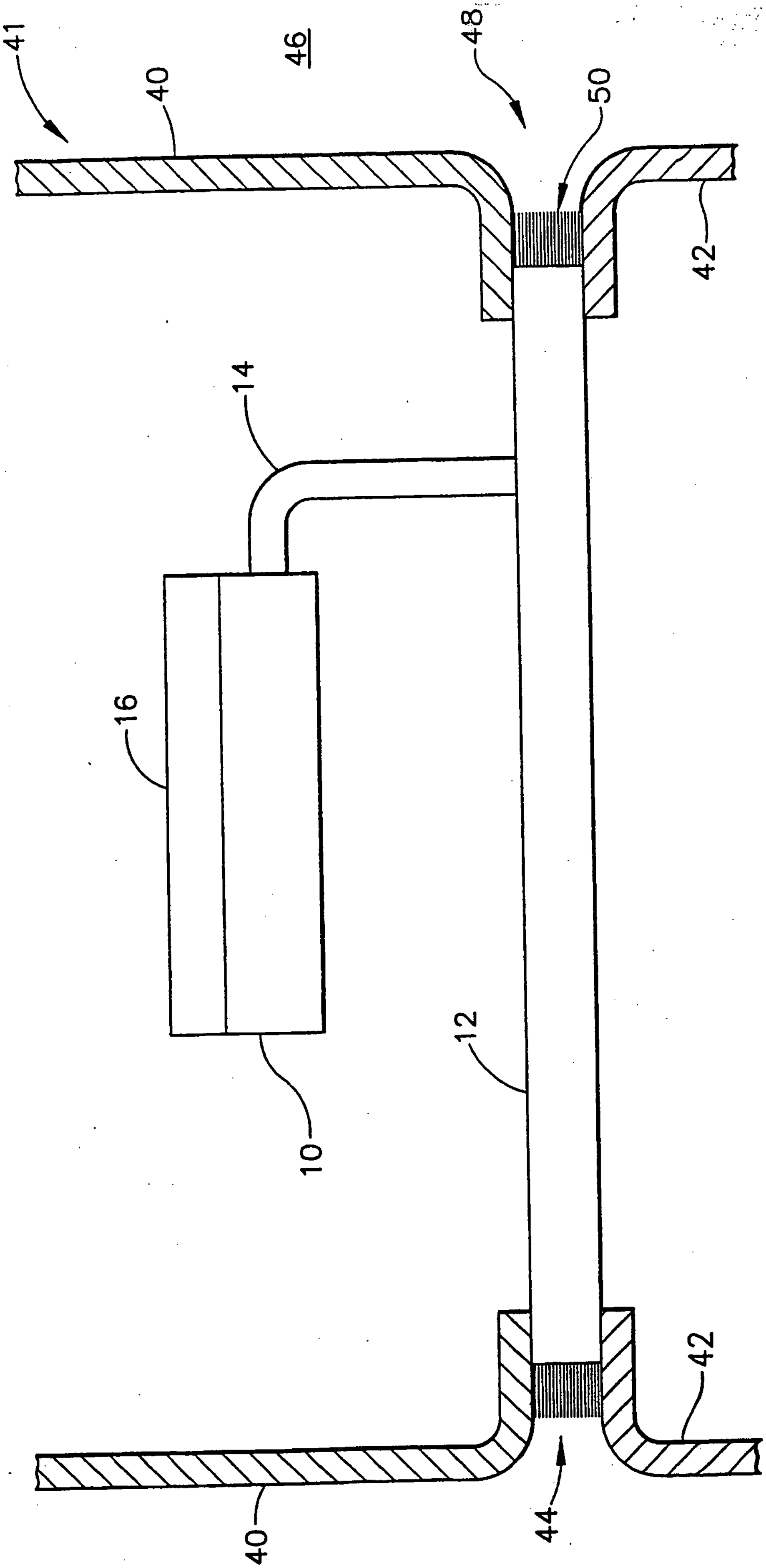

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05K7/20 H01L23/367 F28F21/02 G06F1/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05K H01L F28F G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 97 30321 A (ALLIED SIGNAL INC) 21 August 1997 (1997-08-21) page 3, line 22 -page 3, line 24 page 4, line 10 -page 4, line 13 page 8 page 10, line 17 -page 10, line 31 ---	1,5
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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International Application No
PCT/US 00/01058

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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